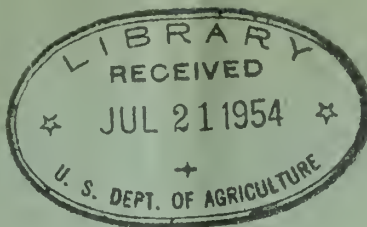


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THE VALUE OF SCIENTIFIC RESEARCH,

Outstanding Achievements

Of the

UNITED STATES DEPARTMENT OF AGRICULTURE //

A Record of Progress

for Humanity

Compiled by the
Press Service

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1921

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"We taste the spices of
Arabia, yet never feel
the scorching sun which
brings them forth----."

FOREWORD

It is doubtful whether there is anywhere in American literature a more absorbingly interesting romance than is to be found in the wonderful story of the rise from small beginnings, the marvelous development, of the United States Department of Agriculture. To the average mind, perhaps, this is an anticlimax, because to that kind of mind the mention of agriculture brings visions of plowing and planting, of reaping and binding, of wearisome hauling, of sweat and dirt -- the little, uninformed mind, satisfied with surface indications, content to plod along without digging into the depths of things. To the searcher after fundamentals, big truths, the effects that grow from great causes, the mighty progress of this governmental department pictures a world filled with achievements by men whose names scarcely are known except among the learned or thoughtful, achievements that have had for many years, and will have for generations yet to come, an influence on human living almost beyond the grasp of ordinary intellects.

Someone, some day, will gather into book form -- and it will not take many pages -- the really great, history-making, race-developing documents of America. When this is done these papers will be found in the forefront: The Constitution, the Declaration of Independence, and the Morrill Act, which made possible the land grant colleges of this country, and led inevitably to the organizing of the United States Department of Agriculture. From the Morrill Act, and the enactments

following as a result of it, have grown up 50 agricultural colleges in the States and the Insular Possessions. There are 67 experiment stations supported by State and Federal appropriations, either on the continent or in the islands under the American flag.

What a strange mentality it is that sees only buildings and thinks only of appropriations in contemplating such growth! What a cramped intelligence that thinks only of individuals in discussing the expenditures of such an organization! How narrow the viewpoint which refuses credit to men and women devoting their lives, often for inadequate compensation, in the interest of human advancement! How sordid the brain that can not realize the unselfishness of these workers for the common good!

What an awakening it might be if only the people as a whole could see into the obscure corners of the many buildings in the National Capital, in the basements, the attics, the fields of the big farm where these servants of science are searching day after day, year after year, for the wonders of plant or animal life that they may add to the comfort of a hungry world! What a transformation might come over public thought could the people go with the explorers into the far corners of the earth, across the seas and deserts, braving dangers unknown to the stay-at-home, for some plant or animal, some seed or insect for the improvement of American agriculture or its protection, and finding in the accomplishment an unselfish satisfaction beyond the understanding of thousands to whose peace and happiness the work contributes!

"White collar jobs!" A day spent among these over-allied, dusty, grimy men of science, in laboratory or field, would soon give the lie to this glibly uttered phrase. The cotton fields of Egypt, the wheat fields of far-off Russia, the plains of Manchuria, the distant provinces of China, all have added to the fund of information gathered by these faithful servants of the people; and men talk of "white collar jobs!"

Some of the things these men have done are set down here. In no way is the list complete. Only the outstanding facts have been recorded. In much of the work described it is impossible to give a money value. Results have been accomplished beyond the mere dollar basis. Investigational work leading to definite ends often can not be gauged in actual cash saved for the people; in others the figures are given arbitrarily. An astonishingly large amount of departmental effort, some of it requiring years of labor, has gone to the wholesome improvement of living conditions in rural regions, and a great deal of it affects those conditions in the congested centers of population, where clothes are worn and food is eaten without a thought of its origin or of the effort that went into its creation.

From the fruitful groves of California to the vineyards and farms of New York and New England; from the forests of the Far North to the fertile fields of the South; the wheat belt of the Middle West and the corn fields, come proofs of the Department's great work for the race, and not only in America, but for those across the seas whose Macedonian cry for help the Nation heeded in a time of great stress.

Washington, D.C. July 22, 1921.

The Press Service.

SAVING MONEY FOR FARMERS

A new irrigation project in Utah had indicated, in 1913, that the irrigation or water right was to be \$80 an acre. The farmers thereabouts declared that this rate was too high and asked the Bureau of Farm Management and Farm Economics in Washington to make an investigation to determine, if possible, whether the profits in farming in that region were sufficient to bear such an expense. The investigation showed that the farmers' contention was well founded, that they could not afford such an expenditure, and as a result the rate was reduced from \$80 to \$40 an acre. There were approximately 8,000 acres under irrigation in this project. The saving to the farmers at \$40 an acre amounted to \$320,000 a year. ✓

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A farmer had given a survey record of his farm business, which fell below the average of his community. It had not impressed him strongly, because he feared that perhaps his survey record was inaccurate. He kept a farm account book the next year and when it was worked out his returns were again found to be below the average. This time he was interested because he believed his record was accurate, and the results, as compared with his neighbors, probably were correct.

"Now," he said, "please tell me what's the matter with my farm. I know I am not doing as well as my neighbors, and I want to know the

reason. Don't be afraid of hurting my feelings. Just tell me what is wrong."

Several factors were worked out, and this man's record compared with the man's record who for over three years had averaged the best in the community. The factors were as follows:

	<u>Best Farm</u>	<u>Farm 1.</u>
Interest earned on the investment	11.1%	4.6%
Size of farm (acres)	178	120
Crop yields (Crop Index)	92	98
Livestock returns for \$100 invested	\$150	\$80
Crop acres per man	73	49
Crop acres per horse	21	14
Operating expense for \$100 income (Cash expenses, all labor and depreciation)	\$20	\$46

On the basis of these figures, it was pointed out that the best farm made more than two times the net earnings on the investment that the poorer farm had made. It was shown also that the largest difference in the two farms was the size of the business. The man on the larger farm worked 73 acres of crops with each man and 21 acres of crops with each horse. His cash expenses and depreciation amount to \$20 for \$100 income. The other man on his smaller farm had to hire a man for part of his work and needed about a certain number of horses to operate modern machinery. As a result, he was working only 49 acres of crops with one man and 14 acres of crops with one horse, on the average. The operating expenses were high accordingly, amounting to \$46 for \$100 gross income.

After the comparison the farmer said, "I see the point, but did not realize how much difference it made in the results. I think I can

remedy the situation by renting 40 acres adjoining my farm."

A year later he went to the central office, and his greeting was: "Well, I have a better record than I had last year." Then he told his story. He had rented forty acres additional, and had been able to operate the farm without buying any new equipment in the way of either buildings or machinery, without buying any more horses, and without hiring any more labor than he had the year previously. As a result, he had worked 71 acres of crops with one man, 20 acres of crops with one horse, reduced his expenses from \$47 for \$100 income to \$22 per \$100 income, and as a result, made a better rate of interest on the investment than the man with whom he was compared, the previous year. The lesson had been driven home and he knew how to analyze and study his own record.

No attempt can be made to give the total savings resulting from this service.

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CUTTING DOWN INSURANCE RATES

Special attention has been given in the Bureau of Farm Management and Farm Economics to fire insurance for farmers, about 43 per cent of which insurance, amounting to over six billion of risks, is now carried by Mutual Companies controlled and managed by the farmers themselves. Many phases of this form of rural cooperation have been carefully studied and suggestions made for improved plans of organization and more efficient methods of operation.

These companies are saving the farmers about \$20,000,000 a year in reduced cost of fire insurance. Just what part of this saving can properly be credited to the work of the department it is not possible to say. If 5 per cent of the savings were so credited, it would amount to a million dollars annually. As bearing upon this point, Harry P. Cooper, Secretary of the National Association of Mutual Insurance Companies, which association is composed to a large extent of farmers' mutuals, wrote recently to the Bureau:

"More and more the wide-awake companies are depending upon you and your work. I think there is no single influence that has had more to do with the farm mutual business than the work which you are doing. * * * * I am quite sure that if we should take an inventory now, that we would find a great many companies who are adopting the plans and practices which you advocate."

Research work in agricultural geography has been in progress for several years in the Office of Farm Management. When America entered the great war, and desired information regarding the world's food supply, the "Geography of the World's Agriculture" was put together quickly from the results obtained formerly, and published at a time when this information was invaluable. The experts in agricultural geography in this office were called upon by the Colonel House Commission on the Peace Conference to prepare agricultural maps of Europe that would be useful in studying boundary lines at the Peace Conference. Dr. Bowman and other advisers of the Peace Conference said these maps were of great value, and far superior to anything any other country had available for the conference.

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DISCOVERIES WORTH MANY MILLIONS

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Some of the Important Results of Scientific
Research by Department Experts.
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It is believed that the Bureau of Entomology was the first to introduce arsenate of lime as an insecticide, although it had long been known as a chemical. After considerable experimentation, it has been ascertained that this arsenical is a perfect substitute for Paris green, costing about one-half as much, that it can be used in many situations where arsenate of lead has been used, with a saving of perhaps 30 per cent, and that it can be combined with certain fungicides to much better advantage than other arsenicals. Introducing arsenate of lime as an insecticide, it is believed, will save the crop growers two to three million dollars a year.

SAVING A STATE'S WHEAT CROP

In the grasshopper extermination work in 1917 and 1918 a saving of not less than ten million dollars resulted from campaigns started and participated in by the experts of the bureau. In Kansas 1918 was remarkable for one of the worst grasshopper outbreaks that have occurred for many years. During the fall of 1917 a grasshopper egg survey was instituted in cooperation with the State Agricultural College. This survey showed that a great hatching of grasshoppers was imminent, and plans were immediately made to combat the pest. Winter meetings were held throughout the infested region and plans matured for preparing poisoned baits in large quantities. It is estimated that as a result of this campaign 113,000 acres of wheat were saved from destruction. With wheat at \$2 a bushel, the value at that time, there was a saving of approximately three million dollars in Kansas on the wheat crop alone. Moreover, it is estimated that 100,000 acres of alfalfa were saved in western Kansas, representing a value of \$2,500,000.

North Dakota officials say that cooperative work between this bureau and the State in a similar way resulted in the saving of between eight and ten million dollars.

WHEN PEARS, PRUNES AND CHERRIES WERE IN DANGER

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Thrips appeared in pear, prune and cherry orchards in the Santa Clara Valley, California, about 1903, and caused extensive losses. The ~~insect~~ spread rapidly and increased in injuriousness, so that by 1905 or 1906 the annual loss to the fruit growers in central California was perhaps one-half million dollars. The Bureau of Entomology, after careful investigation of the insect, developed an effective and economical treatment which was at once adopted by the orchardists, and has enabled them so thoroughly to keep the insect in check that subsequent losses have been inconsequential. ^{one} ~~He~~ estimates this saving at less than one-half million dollars a year.

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AND THEN CAME PARADICHLOROBENZENE

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The peach-borer, a native insect, has ravaged peach orchards in this country from the earliest times. It has been the cause of the death of more trees than all the other insect enemies of the peach combined. Recently the bureau developed the paradichlorobenzene method of treatment, which, since its announcement two or three years ago, has come into very large use by commercial peach orchardists with uniformly satisfactory results. It is believed this method will result in the saving to peach growers of from three to four million dollars a year. A grower in Georgia who controls several hundred thousand peach trees, advised the bureau recently that this discovery is worth all the bureau has cost the country to date.

THE COSTLY ONION THIRP

Not many years ago thrips seemed about to ruin the entire onion industry of the United States. The research work of this bureau, using a fund of only \$3,500, resulted in a saving which was pronounced by a certain Congressman from Indiana to amount to one million dollars in his district alone. Onion growers in other sections have declared that the careful use of the methods worked out by this bureau will control the thrips and will save the crop, if applied in time, even in the most extreme cases.

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THE LADYBIRD'S FINE WORK

When Australian ladybirds were introduced into California by the Bureau of Entomology all the citrus growers were hopeful, but most of them doubted that this bug could drive out the white scale. The project was successful, and the citrus industry was saved. It is scarcely possible to tell this ⁱⁿ terms of dollars, because the amount would never be understood or believed. It was scientific research alone, and the most painstaking, that resulted in the ladybird's being brought to America. Truck growers in tidewater Virginia ^{say} it has resulted in an annual saving of at least two million dollars through controlling vegetable-destroying plant lice. No serious outbreaks of these lice have been experienced since this work was done by the bureau.

MILLIONS IN SWEET POTATOES

It was the research work of this bureau on the sweet potato weevil in Alabama, Mississippi and Georgia -- States having an investment of more than forty million dollars annually in this crop -- that saved for those States at least six million dollars, and possibly ten million dollars to date, the weevil being, apparently, completely eradicated by a system worked out by the bureau.

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SAVING ALFALFA AT \$1 AN ACRE

The alfalfa weevil, a European pest of great importance, became established near Salt Lake City in 1904-05. Investigations were initiated at once, and these have resulted during the past few years in the discovery of a practical method of control which costs about one dollar per acre and which insures protection for the alfalfa crop in the infested region. The saving effected by this method is not less than \$250,000 a year in Utah alone. The same method is now being used in Idaho, Wyoming, and Colorado for the control of the insect.

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ONE BUG AGAINST ANOTHER

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A poisonous, destructive caterpillar appeared on the cattle ranges of northeastern New Mexico in 1911-1912. This insect destroyed the range grass and seemed likely to render the land almost valueless. After investigation, the experts of this bureau decided that only one method of control seemed feasible, namely, introducing the natural enemies of the pest. This was at once begun. During the following three years the pest almost completely disappeared. It is believed that the natural enemies subdued the insect, and the resulting saving has been many hundreds of thousands of dollars. Science knew the answer. X

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SAVING FOOD FOR THE NAVY

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Although not involving such large sums of money, this instance is interesting as giving some very exact figures. They are available as a result of cooperation between the Bureau of Entomology and the United States Navy. About 750 tons each of rice and navy beans are under consideration. The saving effected in this single instance is 26.9 times the amount of the appropriation for Stored Product Insects recommended to Congress by the Committee on Agriculture (H.R. 12,272; February 16, 1920) for the fiscal year ending June 30, 1921.

The Navy purchased 1,530,492 pounds of rice at \$0.07265 per pound, or \$111,190.2438. When found slightly infested with the rice weevil and recommended for treatment, steps had already been taken to salvage the

the entire lot for \$0.0375 per pound. Had the rice been sold at this figure, the loss would have been \$53,796.79. Instead, the supply was reconditioned at a cost of \$0.00832 per pound, or for \$12,733.69, and sold after reconditioning at \$0.0675 per pound, or for \$103,308.21. The saving thus effected by the treatment of the rice was \$33,181.07.

Navy beans to the amount of 1,322,614 pounds were purchased by the Navy at \$0.0925 per pound, or for \$122,341.795. When recommended for treatment they were about to be sold by the Salvage Department for \$0.0375 per pound, or for \$66,130.70. Instead, they were reconditioned at a cost of \$0.007 per pound, or for \$9,258.30. After being reconditioned they were sold at \$0.09 per pound, or for \$119,035.26. Thus the saving effected by the treatment was \$43,646.26.

A total saving to the Navy Department for the two operations of \$76,827.

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DEFEATING THE HESSIAN FLY

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It is difficult to give exact figures with such insects as the Hessian fly, the chinch bug, the codling moth, and the plum curculio. Years ago, when the wheat crop was much less extensive than at present, there were years when the loss from Hessian fly amounted to 60 or 70 million dollars. The careful studies of entomologists have determined dates fly-free_^ for sowing, and the bureau has analyzed so carefully all the factors involved as to find a bioclimatic law, so that the proper date

can be reached no matter what the latitude, longitude or elevation of a given farm may be. Very many millions of bushels of wheat are saved by the observance of these fly-free planting dates; and, by a general understanding and observance of the now formulated principles, serious Hessian fly damage will become inconsiderable.

Similarly, the coordinated winter destruction^t of the chinch bug in hibernation, and the proper spraying for the codling moth and the plum curculio, all based on research work by entomologists, result each year in the saving of an enormous amount of money to the country as a whole. To attempt to estimate it is hazardous.

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PARASITES OF THE MOTH FAMILY

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Research work of the bureau, the adoption of the remedial measures discovered in this work, and its introduction of European and Japanese parasites of the gipsy moth and the brown-tail moth, have resulted in holding these insects in check in New England, greatly reducing their numbers there, and in preventing their spread for more than twenty years. If this had not been the case, the mixed forests of the Northern States would have been seriously damaged and the orchardists all through the same area would have been burdened with the enormous load of a constant year-to-year fight against these ravenous insects.

CHECKING A LOSS OF MILLIONS

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It has been estimated by competent authorities that the annual losses in this country from insects and fungi is in excess of \$1,500,000,000. It is the belief of the Insecticide and Fungicide Board that these losses would certainly have been 20 per cent greater if insecticides and fungicides had not been used. The use of insecticides and fungicides was therefore responsible for a saving of \$300,000,000. The Board believes that at a conservative estimate the enforcement of the Insecticide Act, the publication to manufacturers of scientific information, and the restraining and moral influence created by the mere existence of this punitive statute are together responsible for at least 5 per cent of the saving resulting from the use of insecticides and fungicides, or \$15,000,000.

Based on another conservative estimate, the total gross sales of insecticides and fungicides in the United States in 1919 (the latest year for which an official estimate is available) are believed to have been in excess of \$30,000,000. The enforcement of the Insecticide Act, resulting in reducing the quantity of short weight materials and increasing the proportion of high grade commercial remedies, is believed to have been responsible for saving to the consumers fully 10 per cent of the amount represented by these gross sales, or \$3,000,000, thus making a total return to the American public, through the money invested in the enforcement of the Insecticide Act, of \$18,000,000.

ON THE TRAIL OF THE BOLL WEEVIL

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Tireless research resulted in the discovery of calcium arsenate dusting to protect the American cotton crop against the ravages of boll weevil. This pest has been so destructive as to drive some highly prized classes of cotton practically out of the field. To gain some idea of the damage done, it is recorded that on parallel rows, half of which were treated with calcium arsenate and half untreated, the difference in yield has been shown to be 40 per cent.

At the time the calcium arsenate treatment was developed by the Bureau of Entomology, calcium arsenate was not extensively manufactured. The situation called for immense quantities. The Insecticide and Fungicide Board in collaboration with the Bureau of Chemistry, worked out a system of large-scale manufacture, which was described in a department bulletin entitled "A Method for Preparing a Commercial Grade of Calcium Arsenate." This bulletin was distributed among manufacturers. From a few thousand pounds manufactured annually, the output in 1919 rose to about 3,000,000 pounds and in 1920 to about 10,000,000 pounds. Most of the manufacturers of calcium arsenate followed the method outlined in the bulletin, and as a result of the publication of those few thousand bulletins, the grade of calcium arsenate sold on the American market is much improved.

The cotton boll weevil entered the United States, by way of South Texas, in the early nineties. It has spread from year to year until it now occupies nearly the whole cotton belt. Investigations were begun at once by the Department of Agriculture, but were temporarily abandoned when

the State of Texas took up active work. The investigations by this Bureau were resumed in 1901, and since that time progress has been made every year in the discovery of new methods of reducing the damage by the weevil and of growing cotton in spite of the weevil. The annual loss to the cotton crop, reaching from 15 to 20 millions of dollars a year during the early years and now possibly reaching 100 millions of dollars a year, would have been infinitely greater had it not been for the immediate application by very many planters of the results of the investigations by the government entomologists. Within the last few years we have found that by the use of calcium arsenate approximately a 40 per cent increase in the yield of cotton can be brought about in weevil-infested cotton fields as opposed to similar fields where no poison is used. Therefore, if the poison were universally used it would result in a saving of between 35 and 40 millions of dollars a year. However, this system of boll weevil control is not yet universally used. At the present time it is estimated that the actual saving from the application of this remedy is approximately one million dollars a year. X

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CHANGING THE NATION'S COTTON CROP

The Egyptian type of cotton is remarkable for the length, strength and fineness of its fiber and is much in demand for the manufacture of mechanical fabrics requiring exceptional strength and durability, and of fine dress goods, sewing thread and other products. Large quantities of this cotton are imported annually into the United States, amounting in 1919-20 to nearly 500,000 bales of 500 pounds.

The United States Department of Agriculture, recognizing the desirability of producing cotton of this type on our own soil, began many years ago to introduce seed from Egypt and to test it in various parts of the cotton belt. Climatic and other conditions in the Southeastern States proved unsuitable but preliminary experiments gave promise of better results on the irrigated lands of southern Arizona and California, although it was evident that acclimatization and the selection of new varieties would be necessary to adapt the crop to the new environment.

Plant breeding work in that region, as well as a systematic study of the behavior of the plant in relation to the environment both in Egypt and in Arizona, were initiated 20 years ago by the Bureau of Plant Industry. This work eventuated, in 1908, in a new variety, having fiber of the Egyptian quality and averaging about $1\frac{1}{2}$ inches in staple, which received the name "Yuma."

During the next four years this variety was tested thoroughly at field stations of the bureau, and, through cooperation with manufacturers, the spinning qualities of the fiber were determined. The results having been satisfactory, seed was distributed to farmers in Arizona and California

in 1912 and Yuma cotton became the basis of a new agricultural industry.

Breeding work was continued in the hope of producing a still better cotton, and in 1910 a plant was discovered in a field of Yuma cotton in Arizona from which was developed the Pima variety. Careful tests of Pima during several years proved it to be superior to Yuma in fruitfulness and earliness, as well as in length of fiber, the staple averaging 1-5/8 inches. Consequently, in 1916, steps were taken to substitute the new variety in commercial production and since 1918 it has entirely replaced the older Yuma type.

The production of American-Egyptian cotton showed a fairly steady increase from 375 bales in 1912 to approximately 95,000 bales in 1920. A conservative estimate of the aggregate value to the growers of the fiber and seed produced in Arizona and California during the years 1912 to 1920, inclusive, gives a total of \$54,739,000. The great bulk of the crop, in each of these years, has been produced on the Salt River Reclamation project in Arizona, and the aggregate value of the product in that locality represents more than four times the total construction cost of the project, including the Roosevelt Dam.

Pima cotton has found its chief utilization in the manufacture of tire fabrics, but is also manufactured into sewing thread, dress goods and other articles in which great strength or a handsome finish are required. During the war it was found to give thoroughly satisfactory results as a substitute for Sea Island cotton in the manufacture of fabric for airplane wings and military balloons.

The American-Egyptian cotton industry is essentially a product of research work in the Department of Agriculture. Lines of investigation by the Bureau of Plant Industry and the Bureau of Markets which have contributed to the successful establishing of the industry, in addition to the plant breeding work which yielded the new varieties, have been:

1. Study of the behavior of the plant under the climatic and soil conditions peculiar to the Southwest, resulting in the development of improved methods of planting, thinning and irrigating the crop.
2. Study of the reasons for the degeneration of commercial varieties of cotton, leading to the development of the idea of community organization on the basis of a single variety. As a result, Pima cotton growers of the Salt River Valley realize thoroughly the importance of limiting the community to a single variety and of carefully maintaining the purity of the planting seed.
3. Experiments in classing the new product, which resulted in the establishment of official grades and standards for American-Egyptian cotton.
4. Technological investigations, cooperative in part with manufacturers, to determine the spinning value of the fiber in comparison with imported Egyptian and other commercially established cottons and to ascertain for what classes of manufacture it is best adapted.

On account of the great volume of production in the cotton industry even the most conservative estimates of values of improved varieties and methods, on millions of acres of land, run into enormous figures. Recent reports from North Carolina give \$28.97 an acre as a five-year average of the advantage to the farmers of replacing poor varieties with good ones, with an estimated total of 41 million dollars that would be gained in that State if all of the farmers planted good seed. From south Texas an

increased return of \$27.56 an acre is reported from planting Durango cotton, or \$66,000 from a single carload of seed planted by a local community of the Lower Rio Grande Valley.

The potential value of the varieties and cultural improvements, if extended and applied to the entire industry, might amount to nearly 50 per cent of the present production, or several hundred million dollars annually, in making the crop more valuable or in reducing costs of production. Replacement of present inferior, mixed stocks by superior, uniform varieties would give a direct gain of at least 10 per cent in quality, and as much more in yield, while another 10 per cent might be expected from the cultural improvements that become possible in one-variety communities. Advantages from community handling and marketing of a standardized product would not be less important than the other items.

All of the recent applications of botany in the cotton industry are based on the research work that has been done in the Department of Agriculture. The essential facts about the cotton plant that have served as the basis of our practical applications have not been compiled or derived from other sources of information outside of the department, but from first-hand observations and experiments. The facts were not known previously, and there is no reason to believe that such investigations would have been made elsewhere if the research work had not been undertaken by the Department of Agriculture.

The bureau has conducted tests to establish the relative spinning value of different varieties of cotton and of the different grades of the United States official cotton standards. The benefits to farmers by these projects have amounted to many millions of dollars on a small investment.

When an investment of \$3,000 makes possible a two million dollar benefit to the farmers of the country, it is worth while. This is what is being done in the investigations into methods of delinting and recleaning cotton seed for planting purposes. Cotton seed as it comes from the gin contains a coat of short lint, which retards germination and hinders the operation of recleaning and grading apparatus and planting machines. It is estimated that 30 million pounds of lint and 100,000 tons of cotton seed are wasted as a result.

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IMPROVING OLD WORLD PRODUCTS MEANS FORTUNES FOR THE NEW

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The date palm was practically an unknown plant in America in 1898. Today there is a date industry worth \$275,000 in the Southwest. This could never have been accomplished without scientific research work of the highest order. The discovery of the entirely new and most destructive scale insect, Phoenococcus marlattii, was made ^{and} a method found to kill it. The method of hot bed tents for rooting the suckers of the date palm, the method of ripening the fruit in paper bags and processing them in ovens are all examples of the scientific research which has been essential in establishing this new industry. Today American publications on the date palm are the standard works of the world on an industry which has been in existence since the dawn of history, and American experts know more about the date palm than any other experts in the world.

When the Sudan grass was introduced in 1909, it appeared to be so much like Johnson grass that there was much opposition to its dissemination. It was feared as a weed. A scientific botanical study of its habits showed it to be a distinct species of grass and one not to be feared in any way. As a result of the systematic study of its habits, adaptability to certain soils and climates and uses for fodder, there were grown in 1918, just nine years after its introduction, 499,166 acres yielding \$10,400,000 a year in fodder.

Avocado growing is becoming a new and valuable industry in America. There are already over 1,000 acres in avocado groves in California and Florida, and a single grove shipped 10,000 crates of this new fruit to market last year. Scientific research has proved there are three distinct types of avocado, varying in hardness and ability to resist cold and drought. The West Indian avocado is a complete failure in California, whereas the Guatemalan and Mexican hybrids of these succeed there. Scientific investigations have worked out the diseases of this tree, the methods of controlling them, the methods of propagation and proper fertilization, and explorations by a trained agricultural explorer have discovered and introduced varieties far superior to those already finding their way into America by chance. The industry is worth already \$1,000,000 and is in its very infancy. On the scientific investigation of this industry not over \$5,000 a year for the past 10 years have been spent.

The dasheen is an example of what scientific research has done in establishing an entirely new food crop in this country. Although millions of people live on this dasheen in various parts of the world, no use was made of it in America, although as far back as the time of the Civil War, tubers of it were brought in and grown in the South. The world was searched

for varieties of it. These were grown in plot experiments and the best variety selected. This variety was propagated by the thousand and tested in hundreds of places. A nematode disease attacked its tubers, but, through scientific research, a method was worked out of killing it with water heated hot enough to kill the nematode without killing the tubers. The methods of harvesting, storing, packing and cooking were worked out in great detail, and today the tropical West Indian Islands have come to this country for the publications on the dasheen, a crop which they have grown for centuries. The popularization of the dasheen and the production of special products from it are part of the successful establishment of it as an industry for the South where fall potatoes are a failure.

Pear blight is one of the most destructive diseases of any fruit tree and causes millions of dollars' loss annually. There is no story more romantic than that connected with the discovery of its cause by a bacillus 40 years ago and its spread by bees, but the solution of the problem it is now understood lies in the introduction of blight resistant species of pears to use as stocks and to grow as direct producers. The discovery by Reimer of Oregon of a way to test the resistance of young pear trees to the blight and by Frank N. Meyer of the Ussurian pear in North China and the calleryana pear in Central China are two scientific discoveries which are leading already to the control of this disease. Thousands of pears are now being worked on these resistant stocks.

The peach is subject to alkali in the Southwest, and areas where much alkali accumulates can not be used for peach culture. Frank Meyer discovered in China a wild peach which grows well on soils too alkaline for ordinary peaches, and this is now being used on an extensive scale as a stock for the cultivated peach.

It was plant pathological research which determined the cause of the chestnut blight and scientific agricultural exploration which located the disease in China and proved that its home is there and brought back from China resistant species which are now being grown on a small scale in America and which may quite possibly supply the chestnuts of the future. Other species exist in China and must be secured. New forms were brought back this year by the Agricultural Explorer Joseph F. Rock.

The Chinese jujube which is destined to be a most important crop in the West, because it never fails to fruit, will stand ill treatment and produces a delicious new (dried) fruit, comparable with the date in quality, is an example of scientific research work. The agricultural explorer, Frank N. Meyer, made a careful survey of North China and gathered all the varieties to be found there. The establishing of variety collections, and their study by experts in this country have resulted in producing orchards of this fruit, and the adoption by confectioners of sanitary and advanced methods of their preparation for market.

In addition to these examples, which are only a few out of many successful plant introductions, mention should be made of Napier grass from Southern Rhodesia, the money value of which in 1918-19 was estimated at \$50,000; Natal grass, valued in 1918 at \$50,000; Japanese sugar cane, valued in 1918 at \$3,000,000; Rhodes grass, from the Cecil Rhodes estate in South Africa, valued in 1918 at \$1,000,000; Carib grass, valued in 1918 at \$100,000; soy beans, one-fourth of which crop is now composed of varieties introduced by this office and which was valued in 1918 at \$6,325,000; feterita, introduced from the Sudan, valued in 1918 at \$16,216,219; Siberian millet, valued in 1918 at \$1,404,000.

HEADING OFF PROMOTERS OF "WONDER WHEATS"

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Few persons know more than a small number of wheat varieties. As a result, unscrupulous agents appear, frequently with so-called new varieties, "Marvels," and so on indefinitely, all to the money and labor loss of many farmers. *

The department has now completed, and is about to publish a classification and description of the commercial wheat varieties of the United States. This has required seven years of experiments covering the entire country, in which more than 25,000 comparisons have been made. Varieties have been found under nearly one thousand names and these are proved to represent only about 230 actual varieties. For the first time crop students and farmers will be able to learn the characters of any wheat variety.

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BRINGING IN NEW WHEATS

Durum wheats, introduced by the department from Russia, have extended wheat growing in the drier portions of the North Great Plains area. This has been possible through careful search in foreign countries and through long and extensive experiments in this country to determine the best varieties and the districts to which they are adapted. More recently durum varieties highly resistant to stem rust have been developed cooperatively by scientific breeding and selection. Milling difficulties have been overcome gradually. A macaroni industry has developed in the United States and the annual value of the durum crop now is in excess of 50 million dollars.

The department was instrumental 20 years ago in introducing and promoting the culture of the hard red winter wheats in the Central Great Plains area including such varieties as Turkey, Crimean, and Kharkov, of which about 21 million acres now are grown annually. It helped in the production of Kanred, a high-yielding and rust-resistant variety of the hard red winter wheats of which about two million acres were growing in 1920. By extensive and long-continued experiments under dry-land conditions, it has helped to extend the production of these hard red wheats through the Northern Plains of Wyoming and Montana and in the Pacific Northwest, in Idaho, Oregon and Washington, where they have replaced the soft white wheats, which are less valuable for flour making.

In the Far West, where soft white wheats are grown, improved varieties of better milling value have been introduced by the department. Among them are Early Baart now grown on 1/2 million acres annually, a pure strain of Dicklow, the dominant wheat under irrigation in Idaho, and more recently the Hard Federation and White Federation, just now beginning to replace the Pacific Bluestem and White Australian on the Pacific Coast.

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B E T T E R O A T S I N I O W A

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Three outstanding varieties of improved oats have been produced in cooperation with the Iowa Agricultural Experiment Station. In 1920 the Albion, Iowa 103, was grown on 1,250,000 acres in Iowa alone, the Richland, Iowa 105, on 1/3 of a million acres, while the Iowar had just been distributed commercially. As the yield on the average is 3 bushels per acre more than the standard varieties, this means an addition of $4\frac{1}{2}$ million bushels annually to the Iowa oat crop not to mention the increase in other States to which these varieties have spread.

These varieties have been developed from varieties imported from Russia. To accomplish this there was necessary a broad knowledge of American and foreign oat varieties and skill in selection and determining of high-yielding strains.

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THE STICKY BARLEY BEARDS

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Barley beards are a great bother to the grower and to the feeder. Beardless barleys have not been good yielders. Research proves that the bearded barley has a storehouse for the surplus mineral matter taken up by the plant from the soil. In beardless barley this surplus is deposited in other parts of the head, making it brittle and easily shattered. By breeding from varieties which normally take up less mineral matter non-shattering awnless sorts may be developed. In the meantime breeding operations have produced several strains having smooth beards, lacking the rough prickly points of the ordinary beard.

SOME DROUGHT-RESISTANT CROPS

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Dawn kafir, a dwarf variety developed by the Office of Cereal Investigations probably now occupies about one million acres. Dwarf Milo, a low-growing strain improved by the department also is widely grown. Sunrise kafir, a tall but early and rather sweet variety was developed by the department. Federita was introduced from Africa. Eighteen years of field experiments have produced not only these varieties but have developed methods of handling them which make them suitable crops in the Southern Plains area where they largely have replaced corn.

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KEEPING WEEVIL OUT OF CORN

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In the southern part of the United States weevils cause enormous losses in stored corn. Investigation has proved that selecting corn in which the ears are completely covered at the tip by long and close fitting husks prevents a large percentage of this weevil injury in cribbed corn. No other method of avoiding this damage is practicable or economical, but this method is possible to every farmer.

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RICE WORTH 21 MILLIONS A YEAR

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Rice growing on a commercial scale dates back only 8 years in California when the department established its rice station in the Sacramento Valley. The department has determined methods of production, introduced foreign varieties, and developed high-yielding new ones by selection, the latest being Coloro just going out commercially. In 1919 the California rice crop was worth 21 million dollars.

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STOPPING THE ROT IN CORN

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Diseases of root, stalk and ear prevail throughout the corn belt, and have caused in recent years an estimated annual loss amounting to 25,000,000 bushels. The Department of Agriculture, in cooperation with the Indiana Agricultural Experiment Station, began in 1917 the scientific investigation of these diseases. The results to date are as follows:

- (1) Discovery of at least two causal fungi on or in the seed, in the soil, and on decaying cornstalks and other plant refuse.
- (2) Discovery that wheat scab is caused by one of the fungi known to cause corn root rot.
- (3) Effective control of wheat scab by crop rotation and seed treatment.
- (4) Partial control of root, stalk, and ear rots of corn by means of germination trial of every selected seed ear.
- (5) Improved rag-doll germinator makes it possible and practical for every farmer to test his own seed, and plant disease-free seed. All these results have been

derived through technical scientific research. The work has not yet been in progress sufficiently long to enable us to state its value to the farmer in bushels of corn or in dollars and cents.

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GETTING DISEASE-RESISTANT WHEATS

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It has long been known that certain groups of wheats, like durum wheat for example, are more resistant than other groups such as the common or bread wheats. It is known also that certain varieties or pure-line strains are much more resistant than others. The cause of resistance, however, has been unknown. In the case of early maturing varieties, what has been called resistance usually is not true resistance but escaping late epidemics by early ripening. The two most probable causes of resistance are differences in structure of the wheat plant and differences in its chemical constitution.

Several varieties of wheat resistant to one or more forms of stem rust now are being grown commercially. Of Kanred, developed in Kansas, it is estimated that about two million acres were grown in 1921. Kota, a hard red spring wheat developed by the department, has just reached the commercial stage in North Dakota. Among the rust-resistant varieties of the durum wheats are Acme, developed cooperatively in South Dakota; Monad, developed cooperatively in North Dakota; and Mindum, developed by the Minnesota Experiment Station. Pentad, or D-5, developed in North Dakota and

usually known as Red durum, is very rust resistant, but of poor milling quality. All of these varieties are grown commercially in the States named.

Following the extremely destructive rust epidemic of 1916 and the rust investigation expanded immediately thereafter, a strong sentiment for the eradication of the common barberry developed in the upper Mississippi Valley. As a result, an appropriation of \$150,000 was made by Congress for the fiscal year beginning July 1, 1918, and has been continued annually since. The campaign was outlined to cover 13 north-central States: Colorado, Illinois, Indiana, Iowa, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Wyoming.

Field investigation was begun immediately to determine the distribution and abundance of barberries, and widespread publicity was employed to bring home to every person, in city, town, and country alike, the relation of barberry to black stem rust and the necessity of destroying the barberry to protect the wheat crop. During 1918 and part of 1919, strong effort was made to eradicate the barberries in all cities and towns of the 13 States.

Beginning in 1919, a comprehensive farm-to-farm survey was begun, in the progress of which not only the farmsteads but all woodlands were scouted to locate cultivated and escaped barberries. By the end of 1920, approximately 180 counties, or about 20 per cent out of a total of 830 counties requiring survey, had been covered by this comprehensive and intensive plan. To the end of 1920 about 5½ million bushels had been located. Practically all of those located had been eradicated.

The average annual production of wheat in this country for the four-year period beginning 1916 was nearly 784,000,000 bushels (783,849,500). During this period the average annual loss from diseases was 147,318,500 bushels. If this loss could have been saved and the wheat milled the country would have produced 29,463,700 barrels of flour which at 12 dollars a barrel would have a value of \$353,561,400. To check diseases and save as much as possible of this loss is one of the biggest problems of the department. Thousands of dollars are spent on disease control work but, as a result, millions of bushels of wheat are saved.

The campaign to eradicate the black stem rust is an illustration of what the department is doing along this line. It is estimated that in 1916 this disease caused a loss amounting to 160,000,000 bushels of wheat in the United States and 100,000,000 bushels in Canada. Practically every year it extracts an enormous toll from wheat growers.

Pathologists have known for many years that the common barberry was the alternate host for black stem rust and have reported many observations of cereals and grasses more severely rusted near infected barberry bushes than elsewhere. They have determined that both the green-leaved and the purple-leaved forms of the barberry are equally susceptible to rust but that the widely introduced Japanese barberry is immune. Since investigations were begun many striking examples have been studied and mapped showing the first spread of rust from rusted barberries to adjacent grass or grain and the continued spread as the season advanced. In this way it has been possible to trace infection from bushes outward for distances of more than a mile. Such examples have been studied in all the important

Northern States in sufficient numbers to convince the State and county officials and the farmers of the part played by the barberry.

The United States Department of Agriculture, in cooperation with the Minnesota Agricultural Station, discovered in 1916 that there were numerous forms of black stem rust. This is one of the most important developments in rust investigations in any country. It has been thought that black stem rust was the same everywhere. It was known, however, that varieties of wheat known to be resistant in one State or section were badly attacked when grown in another State or section. Research on these has resulted already in the determination of 32 different strains or biologic forms in this country. Under the microscope they look alike and can be separated only by growing them artificially on a series of wheat varieties and wheat allies, like emmer and spelt, on which these different forms react differently.

After determination of a form, the next step is to map its distribution which is a slow and laborious process. Rust specimens must be collected from many localities and grown on the series of determining host plants which requires weeks of tedious experiment. Some of these forms have been found to be apparently of local distribution, while others grow over a wide range of territory, and the work is still in progress.

The existence of these numerous forms makes the development or breeding of rust-resistant varieties a very complex and difficult problem.

FORTUNES FROM FOREST PRODUCTS

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It is not easy to estimate in dollars and cents the great value of the service given the country by the forestry workers. When this branch of the department began its investigations into the subject wood and other forest products were accepted as a matter of course, there was practically no scientific information available regarding them, and practically no realization in the industries most concerned of the need for such information. For a number of years the industries were very indifferent concerning the forest products work. Most of them felt, perhaps, it would never lead to anything which would be really practical or worth while. During the last five years particularly there has been a very rapid growth in appreciation of the work and in its application along a great many lines. There is a rather widespread realization that if forest products are to hold their place in competition with other materials the same thoroughgoing kind of scientific information must be available for them as for the other materials. While this conception has grown in part out of competition and a growing substitution of other materials for wood, it is probably due largely to the activities of the department and the results already obtained.

The best estimate possible to give of the value of such results is taken from a memorandum submitted to the Secretary's office under date of July 28, 1920:

Investigations in forest products, total cost \$332,465.73

Annual value of investigations in forest products:

Saving effected as a result of better knowledge of the mechanical strength of structural timbers and of other mechanical properties of wood, making possible more economical design, better methods of bending furniture, vehicle, and other woods, more efficient box and barrel containers, and reduced shipping losses, \$8,000,000

Saving effected through ^Nreduction of wood decay due to work of Forest Service, and through application of the results of glue, plywood, and airplane investigations, \$12,000,000

Saving due to improved methods in kiln drying, \$5,000,000

Saving due to improved methods of turpentine and hardwood distillation, and to pulp and paper investigations, \$5,000,000

Saving due to information on lumber markets, uses, methods of manufacture, grading, standardization of sizes, and similar matters, \$900,000

Total returns on investigations in forest products \$30,900,000

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"F A I R A N D W A R M E R"

The work of the Weather Bureau does not afford any particularly spectacular examples of the economic benefits resulting from the specific scientific studies conducted by the Bureau. However, the development and application of scientific principles to the collection and distribution of weather reports, advices, warnings, etc., constitute a daily service to the nation, the economic benefits of which are enormous in the aggregate.

It can not be denied that in one phase or another of its work the Bureau comes in closer contact with the people than any other branch of the Government service, except the Post Office Department. There are few, if any, daily papers of the United States that do not publish the weather forecasts, while a large number of them print weather tables, synopses, etc. It is estimated that there are about 110,000,000 people in the United States. Certainly an average of one out of every five of them is interested and uses the daily forecasts and weather information. There is estimated a benefit of only one dollar per annum to each of these 22 million people. As a matter of fact, this probably is far too low.

Much of the work is giving warnings of danger, of which the people would otherwise have no knowledge. There is no means of obtaining a census of the dollar value of such service, but it is tremendous. The hurricane that passed over the Gulf of Mexico last September is an illustration. The barometric depression at its center approached the lowest on record. The Weather Bureau detected this storm for several days

prior to its entering the Gulf and kept shipping informed as to its location, direction and progress. Few ships plying these waters could have survived the full force of the hurricane. It is well within the facts to say that from the time the first warning was issued until the storm struck the south Texas coast at least 50 ships heeded the warnings and steered clear of the storm center. There is no doubt that the saving of ships and cargo from loss and damage, to say nothing of human lives, from the storm alone represent a value in excess of the total allocated to storm and hurricane warning service for the entire year. Again, one of the most terrific storms that has visited the Great Lakes for years occurred in November and warnings were issued well in advance thereof. Not a casualty occurred on the entire Great Lakes.

Shipments of perishable products and cattle in transit are determined in a large measure by the Bureau's shippers' forecasts. The official in charge at Chicago estimates that this character of forecasts saved the shippers of that city one and a quarter million dollars; while New York reports a much larger amount. These shippers' forecasts are made for and used by the business men in all the large cities of the United States. Many business activities are dependent altogether or in part upon information furnished by the Weather Bureau. The enumeration of these interests and the many and direct ways this information affects the economic conservations of the country would require a voluminous report even if stated in epitome.

The estimates given are, in the judgment of the Chief of the Bureau, most conservative. In fact, he has leaned toward an underestimation because he feared that if he had used figures to correspond with his own conviction as to benefits they would tax credence and lose in effectiveness.

Acting No.	Activity	Estimated Cost 1919	Estimated value of returns to interests directly relating to agriculture, horticulture, forestry, etc.	Estimated value of return to commerce, navigation and other interests	Total	Percentage of estimated value to cost of service
1	Weather Forecasts & Warnings.	998,000				
	(a) Daily forecasts & weather information.		5,500,000	16,500,000		
	(b) Weekly forecasts.		600,000	400,000		
	(c) Shippers forecasts.			10,000,000		
	(d) Storm & hurrican warnings.		500,000	15,000,000		
	(e) Cold wave warnings.		2,000,000	5,000,000		
	(f) Frost warnings for truckers, tobacco, cranberry, and sugar growers.		2,000,000			
	(g) Fire weather warnings.		100,000			
	(h) Forecasts & warnings for stockmen.		1,000,000			
	(i) Fruit frost warnings.		1,500,000			
	(j) Forecasts for alfalfa growers.		200,000			
	(k) Fruit spraying forecasts.		100,000		60,400,000	6052
2	Highway Weather Service.	5,000	20,000	50,000	70,000	1400
3	Aerological Investigations; Forecasts & Warnings in Aid of Aviation.	110,000		1,500,000	1,500,000	1364
4	Marine Meteorology in Aid of Navigation; Vessel-reporting.	25,000		700,000	700,000	2800
5	Evaporation & Run-off Investigations.	8,210	10,000	25,000	35,000	426
6	River & Flood Work.	187,500	500,000	1,500,000	2,000,000	1067
7	Mountain Snowfall & Water Supply Investigations.	9,500	200,000	100,000	300,000	3158
8	Climatological Work.	420,000	1,250,000	2,250,000	3,500,000	833
9	Agricultural Meteorology.	95,000				
	(a) Weekly weather & crop bulletins.		500,000	1,000,000		
	(b) Corn & wheat service.		600,000	750,000		
	(c) Cotton region service.		750,000	1,225,000		
	(d) Cattle region service.		250,000		5,075,000	5343
10	Solar Radiation Investigations.	9,500	*	*		
11	Seismological Investigations.	2,500	*	*		
12	Volcanological Investigations.	10,000	*	*		
	Totals.	1,880,210	17,580,000	56,000,000	73,580,000	3913

Note: Accompanying sheets contain a brief description of activities shown hereon.

*No values estimated as this activity is of a research character, the results of which are applied to the forecast work and other projects of the bureau

THE EFFECTS OF MOTOR
TRAFFIC ON ROADS

Investigations into the effect of impact on highway surfaces, conducted by the Bureau of Public Roads, will have a very far reaching effect. The measurement of impact, which has been accomplished for the first time by these experiments, has given to highway engineers their first accurate information in regard to the actual loads sustained by modern highways under heavy truck traffic. Previously, engineers have had no adequate conception of the magnitude of these problems, and highways designed in the absence of this information have failed because of a tendency to underestimate the effect of the traffic. The measurements this bureau has made will enter into the design of practically all the highways in the country hereafter constructed, and no doubt will result in the saving of many miles of roads which otherwise would be destroyed by heavy trucks. At the same time information which has been obtained should be of considerable assistance in the design of motor vehicles. Motor truck manufacturers are manifesting very great interest in the results of the studies on this account.

viewed from this angle alone, if it should be possible to effect changes in the design of motor vehicles which will enable them to withstand the effect of impact to better advantage, and if by changes in design it is possible to save the small sum of \$5 per vehicle on the 10 million vehicles now registered in the United States, this alone would amount to a saving of \$50,000,000. The effect upon the road construction is so far reaching as to be impossible to estimate, certainly it would run annually into millions of dollars. This applies as well to the other highway

researches of the Bureau, such as those which deal with the determination of the moisture content in subgrade soils and the development of better subgrades.

The results of the investigations conducted by the Division of Drainage Investigations in the prairie soils of Alabama would, if they were applied to all the $2\frac{1}{2}$ million acres of such lands, effect a saving of more than the appropriations for the Drainage Division since its organization.

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A DISCOVERY THAT CURBED A \$50,000,000
PEST AND MADE POSSIBLE THE PANAMA CANAL

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Undoubtedly the chief accomplishment of the Bureau of Animal Industry in scientific research was its work in solving the great mystery of splenic, or Texas fever, in cattle. If this work had applied only to cattle it would have been of almost incalculable importance to the human race, but it went farther than this. It led to the discovery, later, of the relationship of mosquitoes and other insects to malaria, yellow fever, sleeping sickness, and various other diseases of man and domestic animals, and through these discoveries, with their consequent bearing on conditions in the Isthmus, made possible the building of the Panama Canal.

The bureau's success in eradicating the southern cattle tick from large areas may be said to rest upon three lines of scientific research, namely: (1) The discovery that the tick is the carrier of the microscopic

blood parasite which produces Texas fever or tick fever of cattle; (2) the study of the life history and habits of this tick; and (3) the development of practicable methods of exterminating the ticks, notably by means of dipping the cattle in a solution of arsenic.

The discovery of the part taken by the tick in spreading the disease was made by Drs. Theobald Smith and F. L. Kilborne working under the direction of Dr. D. E. Salmon, the first Chief of the Bureau of Animal Industry.

While the bureau did not originate the arsenical dip, it worked out improved formulas and methods of preparation, and especially a method of testing and regulating the strength of dipping solutions under field conditions, which have been of great value in the practical work of eradicating the ticks. The work on dips was done mainly by Robert M. Chapin, of the Biochemic Division of this bureau.

The damage done by the ticks, and therefore the saving by tick eradication, has been variously estimated at from \$40,000,000 to \$100,000,000 a year.

The cattle tick occupied a territory from Texas to Virginia, and appeared even in California. The Bureau of Animal Industry declared war on it in 1906. The tick was very promptly eradicated from Tennessee and California. Tick territory was reduced steadily in every State. Mississippi completed the task two years ago, driving a tick-free wedge to the Gulf of Mexico. Then South Carolina cleaned up and there was a tick-free lane to the Atlantic. Louisiana is nearly free. Tick territory is much reduced in every State. Areas that have been freed of ticks total more than 500,000 square miles. The areas still to be freed total only

220,000 square miles or less, and the specialists in charge predict the task will be completed in 1923. This will mean, already means, for that matter, millions of dollars a year in beef and dairy products.

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CUTTING DOWN HOG CHOLERA LOSSES.
A DISEASE THAT COSTS \$30,000,000 A YEAR

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Hog cholera baffled the scientific world for many years. It was thought at one time that the germ responsible for it had been discovered. When efforts were made, however, to produce immunity by preparing a serum by the use of this germ according to established principles of immunology, it was found that a serum based on this germ would not always protect hogs against the disease, and that there were cases of hog cholera which were evidently caused by some other agent than the so-called hog-cholera germ. Extensive experiments by Drs. M. Dorset, W. B. Niles, and C. N. McBryde, of the Bureau of Animal Industry, showed that hog cholera was caused by a different germ, one that is invisible even under the microscope and that passes through the finest filters.

Following up this discovery, these investigators developed a method of serum treatment that effectively prevents the disease. The use of this serum in a practical way has brought about a great reduction in the prevalence of hog cholera and in the losses caused by it.

At times the value of hogs destroyed by cholera in the United States has amounted to about \$65,000,000 in a single year, and the average annual

loss for a period of 40 years probably was not less than \$30,000,000.

This represents merely the direct losses; if the indirect losses could be computed, these figures would be greatly increased.

The first period of exceptional prevalence reached its climax in 1887, the second in 1897, and the third apparently reached its height in 1913 and 1914. During these periods the hog-raising industry over the entire country suffered great losses and in some localities was for a time practically destroyed. The estimated number of hogs in the United States in 1920 was 72,909,000. Of these 3,377,032 died of cholera.

The fact that a serum will protect hogs from cholera was first brought to the attention of the authorities in the various States by the Bureau of Animal Industry in 1908-9. Following this, several State institutions began the preparation and distribution of the serum, and subsequently its manufacture was taken up by private concerns. The efficacy of the serum is now recognized generally in the United States and in foreign countries.

Some years ago the Bureau of Animal Industry estimated the annual loss from animal tuberculosis at more than \$23,000,000. Although the bureau can not assert that it has made any such fundamental discoveries concerning tuberculosis as it made with regard to the two subjects already discussed, its research work on this disease has contributed in several respects to the knowledge of the subject and to the development and improvement of practical methods for eradicating tuberculosis in cattle and reducing the danger from animal tuberculosis to human health. The bureau's investigators, especially Dr. E. C. Schroeder, Superintendent of the Experiment

Station, were among those who demonstrated the relationship between human and bovine tuberculosis and the communicability of the latter to man. Bureau veterinarians have improved the reliability of the tuberculin test by the application and development of the ophthalmic and intradermic tests as adjuncts to the subcutaneous test. Improved laboratory facilities, especially an apparatus devised by John T. Bowen for regulating temperature and humidity, have made possible a greatly increased output of reliable tuberculin. The production by the bureau during the fiscal year 1920 was more than double that of the preceding year. These features have been of great practical value in prosecuting the work of tuberculosis eradication.

While tuberculosis is still a common disease, the problem of its final eradication is regarded as solved. Through the accredited herd plan, through prohibiting the shipment of diseased animals in interstate commerce, and by various other means the bureau, with its cooperating agencies, is bringing it under control and pushing it towards final eradication. The records show that in 1917, 9,299,489 cattle were slaughtered, of which 46,351 were condemned because of tuberculosis. In 1919 this loss had been reduced to 37,600 condemned of 11,241,991 slaughtered cattle. The loss of swine from tuberculosis was not so pronounced. Of 40,210,847 slaughtered in 1917 the condemned numbered 76,807. This was reduced in 1919 to 65,838 condemned out of 44,398,389 slaughtered.

Through research, the Bureau of Animal Industry has improved methods of producing vaccine against blackleg in young cattle, and improved the reliability of the vaccine. Vaccine has been prepared in large quantities and distributed to stock owners free of charge. The quantity distributed

in the fiscal year 1920 amounted to 1,757,805 doses. The use of this vaccine has brought about a great reduction in losses of cattle from blackleg.

Discovery, in the course of studies on the parasites of live stock, of the importance of the human hookworm as a cause of disease in the Southern United States has led to a great advance in the improvement of sanitary conditions in small towns and country districts. Other important contributions to science are:

Determination of the life history of the stomach worm of sheep and other ruminants and studies on treatment which have made possible effective control of this serious pest.

Improvement and adaptation of the complement-fixation test, by which accurate diagnosis is made of certain diseases by this blood test. New methods and improved technique have been worked out, extending the application and usefulness of this test and increasing more than tenfold the number of samples that can be tested in a given time.

Contributions to the knowledge of infectious abortion of cattle, leading to progress in controlling and reducing this disease, which probably is second only to tuberculosis in the losses it causes among cattle.

Development of methods of immunization against anthrax in this country. Not only has this work made possible the protection of animals against anthrax, but, as an incident, some serum on hand in the bureau laboratories was the means of saving human life.

Discovery that trichinae in pork can be destroyed by refrigeration at a low temperature for a certain length of time, as well as by certain curing methods, which has led to a system under the Federal Meat Inspection

of safeguarding certain formerly dangerous classes of pork products, obviating the necessity of an expensive and uncertain microscopic inspection that would cost several millions of dollars annually over and above the present cost of meat inspection.

Discovery that "thumps" in pigs is caused commonly by invasion of the lungs by young intestinal roundworms. This has led to the development of practical methods of preventing losses among young pigs caused by these parasites, including not only death losses but also losses from stunting of growth, and other unthrifty conditions which are of frequent occurrence among animals that survive the early effects of the parasitic invasion.

Experiments in beef cattle production. This work is of a fundamental character and new methods are being worked out for wintering cattle to be fattened during the following summer on grass in a way to obtain increased weight with greater economy as compared with ordinary practices.

Horse-breeding experiments, leading to the preservation and improvement of the Morgan breed, the development of a breed of utility horses adapted to western farm and range conditions, and the breeding of better horses for the United States Army.

Sheep-breeding experiments, leading to the development of a type of sheep suited to range conditions, from a Lincoln-Rambouillet cross. The name "Columbia" has been given to these sheep.

Investigations of losses in the egg trade due to fertile eggs, and of means for improving the quality of the farm egg crop by producing infertile eggs. This work has been worth millions of dollars to the farmers and poultry producers of the Middle West. When it began Kansas eggs were the poorest summer eggs received on the market. As a result of applying

the principles worked out in this research, the quality of the Kansas egg was markedly improved in a single season.

Stopping losses on butter held in storage. The development of fishy and metallic flavors and general deterioration in the quality of butter held in storage has caused enormous losses every year to the dairy industry. Some of the factors which cause the objectionable odors and flavors have been determined and a type of butter made from sweet cream has been worked out which may be held in storage for long periods without serious injury to its quality. In fact, it was butter produced under methods worked out by the Dairy Division that solved the problem of supplying the United States with a butter that would hold its quality during long periods of storage, and on shipboard, where cold storage is not available. Many of the creameries which helped to produce the 15,000,000 pounds of butter used by the Navy from 1917 to 1920 have found it profitable to continue its manufacture, and the demand for this type of butter is reported by commercial butter dealers to be increasing rapidly. These results have produced a modification of the methods used by the larger creameries. The former trouble from fishy and metallic flavors in storage butter have been eliminated almost entirely, with an enormous saving to the industry and benefit to the consumers.

Studying problems in manufacture of foreign varieties of soft cheese and making possible their successful manufacture in this country. This work resulted in identifying the fungi producing the characteristic flavor and texture of Camembert and Roquefort cheeses, and in developing processes of manufacture. By the application of this knowledge and these methods, American factories are now producing these varieties of cheese equal in quality to the best imported products.

Improving quality of domestic Swiss cheese. Since the Swiss cheese industry was started in this country millions of dollars have been lost every year due to the inability of our cheesemakers to produce first-class cheese that would compare favorably with the imported product. It is estimated that 80 per cent of the cheese was of inferior quality, or "seconds", and only 20 per cent could be graded as fancy, or No.1. Research work resulted in the discovery and isolation of two living organisms, one of which suppresses the abnormal gassy fermentation, while the other produces the "eyes" and the delicate sweet flavor characteristic of the best imported cheese. These organisms are now being propagated and sent out to the factories in the United States which make this cheese. Under commercial conditions, with proper control of the quality of the milk, about 80 per cent of the cheese made through the use of these cultures will grade fancy, or No. 1, in quality. As this grade of cheese brings an average of 50 cents a pound, and seconds bring only 25 cents, the saving which may be effected on the 20,000,000 pounds of Swiss cheese made annually in the United States is approximately \$3,000,000. There is also the possibility of displacing the 20,000,000 pounds imported annually in normal times, and of greatly increasing the consumption, by producing a better quality at a reasonable price.

Studies of plants poisonous to live stock. For many years heavy losses of live stock have occurred from eating poisonous plants, especially in the western range country. Many poisonous plants have been investigated and identified and their poisonous properties and effects determined. Remedies and means of prevention have also been studied. Numerous publications have been issued, enabling stockmen to recognize and identify poisonous plants and to avoid losses of live stock from this cause.

SCIENTIFIC FUMIGATION THAT PAYS

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The activities of the Federal Horticultural Board are substantially administrative and regulatory. Incidental to the disinfection and control work with respect to plant importations, the Board experts have developed a very important method of plant disinfection by vacuum fumigation. The preliminary experiments were described in Bulletin 186, U.S. Department of Agriculture, "A Method of Fumigating Seed," published February 27, 1915. Subsequent to the issuance of this bulletin, the methods described were altered slightly in order to make it possible to fumigate imported cotton. The experimental work indicated that it was possible to penetrate large bales of cotton and kill the pink bollworm, and as a result of these experiments, the Federal Horticultural Board has required the fumigation of all imported cotton as a condition of entry.

At the present time there are eight commercial firms operating fumigation plants, as follows: In New York, Boston, Seattle and Oakland, Calif.

From March 10, 1916, to June 30, 1920, 1,503,622 bales of foreign cotton were fumigated. It is impossible to express in monetary terms what has actually been saved as a result of this work. We do know, however, that repeated examination of cotton seed contained in these bales has never yet brought to light a single living pink bollworm, although numerous dead ones have been found.

The vacuum method of fumigation has not been limited to the fumigation of cotton, but a small plant at the Inspection House is in constant use, employing hydrocyanic-acid gas and carbon disulphid in the fumigation of various plants and plant products of foreign origin infested

with injurious insects, many of which are new to this country. As in the former case, it is impossible to indicate the saving to this country as a result of the fumigation work at the Inspection House.

As a means of destroying by similar disinfection fungi and bacteria affecting seeds and plants, without injuring germination or destroying the life of the plants, a treatment with formalin gas has been evolved and is in daily use on seeds coming to the Inspection House from all parts of the world.

It is not an easy matter to estimate the value of these methods of disinfection, but perhaps there have been already a million or more dollars expended from private funds for such disinfection of plants at important ports of entry, and products running into a value of hundreds of millions of dollars a year are protected by these treatments.

These items are, of course, only incidental to the main work of the Board, which is to prevent entry of important new plant enemies -- insect and fungous. The Board has been very successful in protecting the country from such plant pests and so far as known no pest of prime importance has gained entry and has become established since the passage of the act in 1912. Furthermore, a very considerable portion of the Board's activities has been directed to limiting or preventing spread -- and in some instances attempting extermination -- of important pests which gained entry, some of them immediately prior to the passage of this act.

The value of this protection and of the control work referred to, to this country, is not easily estimated. Undoubtedly, without such protection, this country would now be losing many hundreds of millions of dollars annually from pests which have either been excluded or have been controlled.

RESEARCH WHOSE VALUE IS DIFFICULT TO ESTIMATE

Cotton is almost the leading crop of the United States. The production of superior varieties of cotton is based upon scientific work conducted in the Bureau of Plant Industry. Taking this work as a basis the Bureau of Markets has striven to popularize the growing of superior cotton through affording proper classification and securing more remunerative market outlets through regular buyers and through cooperative associations. This work has required much publicity to be effective.

The bureau has conducted tests to establish the relative spinning value of different varieties of cotton and of the different grades of the United States official cotton standards. This information has been published for the information of cotton manufacturers and producers.

When an investment of \$3,000 makes possible a \$2,000,000 benefit to the farmers of the country, certainly it is a good investment. This is what is being done in the investigations into methods of delinting and recleaning cotton seed sold for planting purposes. Cotton seed as it comes from the gin contains a coat of short lint which retards germination and hinders the operation of recleaning and grading apparatus and planting machines. It is estimated that 30,000,000 pounds of lint and 100,000 tons of cotton seed are wasted as a result.

SAVING THE COTTON LOSSES

The U. S. Cotton Futures Act and the U.S. Warehouse Act are the result of, and are based directly on scientific investigations conducted by the Bureau of Markets.

Through its work of demonstrating to farmers and others the economy of properly warehousing cotton, this bureau has been instrumental in reducing the losses which accrue on account of improper protection of cotton from the weather. These losses have been estimated to average \$30,000,000 annually. Proper protection of cotton from the weather will reduce such losses to a minimum. It is estimated conservatively that as a result of the bureau's activities more than 300,000 acres were planted to superior varieties of cotton during the season of 1919 in Texas alone, which brought a premium of more than \$3,000,000. During the present season more than 350,000 bales of cotton have been sold by farmers after first consulting with representatives of this bureau as to their grade and value, at a saving to the growers of from \$2 to \$25 per bale. Averaging these sales at profits of \$15 a bale, the direct benefit has been over \$7,000,000.

Far greater indirect results have accrued which are definite and yet intangible and can, therefore, only be approximated. These are the immediate stimulation, adjustment and stabilization of prices on small local markets which are made after the assignment of a representative of this bureau. These readjustments of quotations range fully one-half a cent a pound premium for all cotton sold on such markets.

THE MOISTURE IN GRAIN

The Grain Division of the same bureau recently developed a machine to determine accurately the amount of moisture in grain, which had been estimated by guess, and a standard device and method of determining the test weight per bushel of grain.

The amount of oil in flaxseed is the most important index as to its commercial value, and the test formerly took an entire business day. The department has developed a method which will make known the oil content within an hour.

The establishing of standard grades of potatoes, recommended after investigation by the Bureau of Markets and made effective by the United States Food Administration, made possible the lending of at least \$15,000,000 to potato growers in the stress of the winter of 1917-18.

Another great saving effected by the adoption of the grades, at that time, was the undisputed reduction in the total tonnage of potatoes shipped. Because dealers had to sell upon the basis of the United States grades, bad potatoes were culled out more closely and the railroads were called upon to carry only merchantable stock. A conservative estimate places this saving at 2,300 cars, from February 1 to the end of the season. These cars were released to carry other products equally or more valuable to the successful carrying on of the war at that time.

Another striking example of investigational work relates to the standardization of fruit and vegetable containers. The United States Standard Container Act, applying only to climax baskets, berry boxes,

and small till baskets, reduces the number of climax grape baskets from 31 styles to 3, and the small fruit baskets from 40 styles to 5, simplifying manufacture and eliminating much fraud and deception on the consumer.

A peach-sizing machine, which grades peaches without injuring them, has recently been designed and patented by the department.

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THE VALUE OF CROP ESTIMATES

It is impossible to determine how many farmers, from time to time, take advantage of the crop estimates which reach them direct or through the trade channels. There is another element of economy in the trade in farm products which is made possible by dependable crop estimates; that is, the greater degree of certainty which buyers and sellers can have as to the probable size of the marketable surplus. For instance, if no one knew how much wheat was coming on the market from the 1921 crop the buyers would naturally try to buy at prices low enough to anticipate any effect that an unexpected, large supply would cause. If grain buyers knew absolutely nothing about the quantity of wheat to come on the market, and farmers likewise were ignorant of that, the prices offered to the farmers might, for instance, be as low as 75 cents a bushel. On the other hand, since both producers and buyers know approximately how much wheat is coming from the harvests in this country and abroad, or, enough leaders among producers and buyers know this, there is much less uncertainty in buying grain, and prices may be fixed, for instance, not at 75 cents but

at \$1.25 a bushel. The buyer knows the relative supply and demand and knows what he can afford to pay; on the other hand, the producer likewise knows what the buyer can afford to pay and is prevented from selling at too low a price, or holding until later for a price that never comes. The illustration quoted comparing 75 cents with \$1.25, is purely arbitrary. There is no way of measuring the actual saving due to a knowledge of relative supplies of farm products.

Representatives of the Eastern Fruit Growers' Association declare that the statistical reports on commercial apple crop of 1919, made by the Bureau of Crop Estimates, saved the apple growers at least a million dollars. These reports gave, before the apples were harvested, estimates as to the size of the commercial crop in each producing region. The total United States crop was an abnormally small one; but in some regions the local crops were large and, without the Government estimates, the producers in those good-crop regions might easily have assumed that the apple crop was large generally, and they might have sold at much lower prices than the market justified.

What is true of crop estimates is true also of other statistics used to measure supplies, production, trade movements, price tendencies, etc. It is impossible to measure the actual results of one of these statistical services.

The work of crop estimating is a profession requiring a knowledge of scientific principles relating to agriculture, to economics, and to psychology. The latter element is quite important, for in some data on which statistics are based there is an element of natural bias which has to be studied from a psychological standpoint.

in agricultural statistics in general it is necessary for the leader to understand and apply economics, statistics, and agricultural and commercial geography.

A few concrete illustrations drawn from actual contacts in the Direct Marketing work may serve to show how research work was made use of by producers and the approximate financial benefits. Briefly, the object of the Direct Marketing work, which involved the marketing by parcel post, express and occasionally other methods of transportation from the producer direct to the consumer, was to ascertain and evaluate the factors having an influence on or determining the economic results of such marketing. This naturally involved the matter of containers, especially for parcel post shipments. Based on the determinations reached by these studies a number of bulletins on various phases of direct marketing and the necessary business arrangements and customs involved were issued. The distribution of these, which has aggregated practically one million copies, serve to bring the possibilities of direct marketing before the people of the country generally. The bulletins mentioned have been extensively reproduced in whole or in part by the agricultural press of the country.

One creamery man in New York who was doing a direct marketing business in butter was able to increase his sales, because of contact with the work of this bureau, from a small amount to 480,000 pounds a year. The increase in price to himself and the saving to the consumer he figured conservatively at $4\frac{1}{2}$ cents a pound; this economy aggregating more than 21 thousand dollars for the year.

In another case a Kentucky man, by observing the conclusions reached in direct marketing work, built up an extensive trade in dressed

poultry, etc., in a Tennessee city. He wrote after he had the business going some time, that his problem was not a question of price or of getting the produce to the consumer in a satisfactory manner, but that it was a question of producing or getting produce of a quality required by the class of trade he had built up. This trade was netting him a profit very materially above that usually realized on marketing produce otherwise.

In addition the Direct Marketing project cooperated with the Post Office Department and assisted materially in developing the specifications for containers for shipments of various kinds of produce. The postal rules and regulations specifying the method of packing eggs intended for hatching purposes, when shipped by parcel post, were drafted by Lewis B. Flohr, and adopted as drafted. Such regulations made it possible to ship eggs for hatching purposes when packed just the same as for shipment by other means of transportation, especially express, and during the war as well as since was quite a factor in building up the purebred poultry industry among people remote from express service. The money value of this particular item of constructive service can not be definitely estimated, but it must be worth to the poultry industry of the country many thousand dollars a year.

The work on Marketing Statistics is little more than one and one-half years old and the first bulletin, Department Bulletin No. 982, "Marketing Statistics," is not yet off the press. While, due to lack of data, it is not possible to make a definite estimate of the money value of this statistical work to the country, it would seem that to the cooperative organizations alone the value ought to be several times the cost

to the Government. It is only by thoroughly educating the public to the value and use of data relating to production, available supply, movement and prices, that exploiting and manipulating of the markets can be prevented. This, while not calculable from any specified basis, will evidently be worth to the country quite materially more than it costs.

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MILLIONS SAVED FOR CALIFORNIA

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The California table grape storage investigations were undertaken to devise methods of handling, packing and storage of California table grapes, with a view to extending the marketing season. The factors responsible for the decay and deterioration of the fruit in storage were studied and resulted in the discovery of methods of packing these grapes in redwood sawdust, a waste product produced in California lumber mills, which has extended the storage season of the grapes nearly two months. By the use of these methods the fruit is now kept until the Christmas holidays and later, the annual shipments amounting to approximately 1,200 cars.

The total cost of the grape storage investigations has been approximately \$23,000, and the returns to the growers of California have exceeded \$1,500,000.

Prior to these investigations the storage of California grapes was practically unknown, and the investigations referred to have made possible the development of this industry.

Losses from decay in the storage of sweet potatoes in the South amounting annually to 50 per cent of the crop stored have been greatly reduced through the design of a suitable storage house by the Department of Agriculture, and the building of many thousands of these houses throughout the South. More than four million bushels of sweet potatoes are now stored in these improved storage houses. An increased demand has developed for sweet potatoes in the northern markets because of the better quality of the product, and losses from decay of potatoes stored under the improved conditions have been practically eliminated.

The cost of these investigations was approximately \$46,000, and the returns to the industry through the reduction of storage losses during the last four years have been at least \$10,000,000.

Through an investigation of methods of loading and heating shipments of Irish potatoes for the prevention of losses from freezing in transit, and through the adoption of the methods worked out, the losses from the freezing of this product have been greatly reduced.

The cost of these investigations was approximately \$15,000, and the returns to the shippers, railroads and receivers have been many times this amount.

The losses of potatoes from freezing in transit have been estimated by the shippers during severe winters as exceeding \$3,000,000 annually.

The construction of apple storage warehouses was undertaken to determine the essentials for the proper construction and operation of storage warehouses for apples in order to avoid the severe losses from decay and deterioration occurring in the storage of apples in producing sections. The results have been the development of an efficient type of apple

storage and the building of at least 60 houses of this type in the Pacific Northwest and in eastern apple-producing districts.

The cost of this work during the last five years has been approximately \$43,000, and the saving effected through the elimination of waste in the storage of the fruit has amounted to at least \$300,000 annually.

Work was undertaken to determine the causes of the excessive losses from decay in oranges and lemons. It has resulted in improved methods of handling fruit in the orchards and packing houses, and improved methods of loading, ventilation and refrigeration of the fruit while in transit.

The California Fruit Growers Exchange has estimated that the direct result of these investigations has been an annual saving to the fruit growers of California of \$2,000,000 through the elimination of decay in fruit transit to eastern markets. The cost of the department's investigations was approximately \$60,000.

A marked improvement in the efficiency of refrigerator cars used in the transportation of fruits and vegetables has been made as a result of investigations of the Department of Agriculture in which proper standards for the insulation and construction of these cars have been determined. The improved type of car developed in these investigations was approved and recommended by the Railroad Administration as the United States Standard Refrigerator Car, and is the standard now used in the building and rebuilding of refrigerator cars for fruits and vegetables by nearly all of the railroads of this country. The substitution of refrigerator cars of this type for less efficient cars has resulted in largely reducing losses from deterioration and decay of fruits and

vegetables while in transportation, and has resulted in definite benefit to shippers through the increased value of these products when arriving in the markets in sound, wholesome condition.

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CHEMISTRY SAVES MILLIONS FOR MANY
IN RESEARCH AFFECTING EVERYONE

For several years the Bureau of Chemistry has conducted research work and developed technological processes to prevent spoilage of such highly perishable products as poultry, eggs and fish. The Food Research Laboratory made basic studies of the microorganisms and their methods of work which produced spoilage and as a result made such marked improvements in the methods of storing and handling such products that the losses have been very greatly reduced. Likewise breakage of eggs has been reduced by improvement in methods of making crates and in packing the crates in cars. It is estimated that the saving to the country as a result of this work has been at least \$2,000,000 a year. During the last 15 years it has saved at least \$25,000,000. This is an exceedingly conservative estimate, but since it is impossible to determine how much spoilage would have resulted if the improved methods worked out by the Bureau of Chemistry had not been put into effect, the amount of actual saving can be only approximated.

The bureau is now carrying on important work to improve the methods

of manufacture of table syrup and of cane and beet sugar. Already valuable results have been obtained in improving the methods for manufacturing cane syrup. The bureau did basic work several years ago on the development of improved methods for the manufacture of cane and beet sugar. The bureau was largely instrumental in the early development of the beet sugar industry in the United States. The work of the bureau indicated in what sections of the country beets could be grown profitably for the manufacture of sugar, and many of the improvements in the manufacture of sugar worked out by the bureau have been in general use in the sugar industry for a number of years. It is impossible to form even an approximate estimate of the value of this work, which began about 1880, to the sugar industry of this country.

As a result of investigational work in the Bureau of Chemistry on naval stores, marked improvements have been made in the manufacture of turpentine and rosin and as a result of the standard type samples, great improvements have been made in the methods of buying and selling such products. It is estimated that the savings resulting to consumers of rosin as a result of the uniform system of grading amounts to \$50,000 annually. The work of developing better methods for the production of turpentine has been of considerable financial value to the producers, but there is no way of forming any adequate estimate of the value of this work.

As a result of the development of a method of manufacture of calcium arsenate, it has been estimated that the saving to the country in the protection of cotton, and to the manufacturing industry, is from \$600,000 to \$1,000,000 annually.

The Bureau of Chemistry has been at work for three or four years developing improved methods for dehydrating fruits and vegetables. It is estimated that the annual return to the country as a result of this work is \$575,000.

The work in developing methods for preventing plant dust explosions has been very successful. It is estimated there has been an annual saving of \$7,500,000 in this work in property alone. No money value can be placed upon the lives saved as a result of this work.

The Bureau of Chemistry makes tests of contract supplies of certain products and carries on investigations at the request of other departments. This work is based upon research, although none of the actual testing work can be so classed. As a result of investigations made for the Post Office Department on specifications for postal card paper, the Government has saved \$20,000 annually since 1910. As a result of specifications for lighter paper for use in printing, the Government has saved from \$50,000 to \$200,000 yearly. Not only has this saving resulted to the Government, but a number of magazines and papers have used lighter weight paper as a result of the work of the bureau. Among the magazines which have reduced the weight of their paper from 10 to 20 per cent in the last five years are Collier's, The Ladies' Home Journal, Saturday Evening Post, youths' Companion, and the Literary Digest. These reductions have resulted in savings of not less than \$400,000 annually.

As a result of the investigations relating to the water- and mildew-proofing of materials, the Bureau of Chemistry effected material savings for the War Department during the war. As a result of using specifications prepared by the bureau for water-proofing materials, the War Department

saved \$24,000 on a single purchase. It has been estimated that the work of the bureau added 5 per cent to the serviceability of the tents and duck bought by the War Department during the war. The total amount spent by the War Department for such products was \$132,000,000. On this basis, the work of the bureau saved approximately \$6,000,000.

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MAKING AMERICAN DYES

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As a result of new processes and improvements in existing processes developed as a result of research in the Bureau of Chemistry on the manufacture of dyes, it is estimated that the yearly returns to the country are \$1,500,000, or during a period of four years, approximately \$6,000,000.

Processes for the utilization of waste citrus products have been developed in the laboratory at Los Angeles. It has been estimated that the returns to the public from the utilization of cull lemons is \$300,000 a year, and from the use of cull oranges \$200,000 a year. This is an estimate of the yearly financial return to the country. It continues from year to year and grows with the increased production of lemons and oranges.

CUTTING DOWN THE SHOE BILLS

Important work has been done in developing methods for testing leather, and in improving processes for the manufacture of leather. The Bureau of Chemistry has also developed methods for making leather last longer. If the advice and suggestions of the bureau on better leather and proper care for same were generally followed, at least 50 million pairs of shoes selling at more than \$200,000,000 could be saved. There is no way to determine to what extent the methods developed by the bureau are in actual use, but undoubtedly several million dollars are saved yearly as a result of this work.

The general work of the bureau on the utilization of fruits and vegetables other than citrus fruits can not be estimated with any reasonable degree of accuracy. Many processes for the utilization of fruits and vegetables have been worked out and the results published, and have been used to a considerable extent. Many thousands of dollars worth of fruits and vegetables are thus saved every year.

Under a small appropriation for investigations relating to the application of chemistry to agriculture, the Bureau of Chemistry has carried on through a period of years a number of projects for the improvement of processes for the utilization of fruits, vegetables, and other agricultural products. Chemical research has provided the basis for the technological work of developing the various processes. In addition, under this appropriation studies have been made of the chemistry of plant growth to determine the effect of recognized plant food constituents and

of other inorganic elements applied at different stages, also the effect of light on the composition and physical characteristics of plants and of the changes in composition which take place during the growing periods of plants. Studies have likewise been made of the influence of environmental factors on the composition of crops to determine the role played by the kind and quality of seed and the influence of climatic conditions and the soil on the composition of crops and of their physical characteristics. No estimate can be made of the financial returns to the country of these investigations, but they have been exceedingly useful to agricultural workers in the State experiment stations and to others.

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A LAW THAT SAVES MONEY AND LIVES

While the chief value of regulatory laws insuring the purity and improvement of the quality of foods and drugs is in the factor it contributes to the public health, nevertheless there is a decided monetary value to the country in the economic features of the enforcement of the Food and Drugs Law. The Food and Drugs Act is enforced in a constructive manner and much research work is conducted in order to develop methods for producing foods and drugs that comply with the provisions of the law. Improvement has been made, for instance, in the packing of sardines, in the canning of foods, in the putting up of tomato products, such as catsup, tomato puree and the like, which have been of great value to the industries affected and to consumers of these products, as well as to the agricultural industry which supplies the raw materials.

Great savings have been made to the buyers of stock food through the reduction of adulteration in such products. The requirement that the exact weight of all foods in package form shall be stated on the label has resulted in great savings to the consumer. The truthful labeling requirements of the Food and Drugs Act has reduced to a marked extent the selling of low-priced products for higher-priced products.

It is impossible to estimate the actual saving to consumers by the operation of this law, but the value of the food and drug products which come under the operation of the law is approximately \$13,000,000,000 annually, and if we can assume that the operation of the law results in a saving of 1 per cent, which seems a very conservative estimate, the saving to the people of the United States annually is \$130,000,000.

These figures are estimates, and are only approximately correct. In the very nature of the work, it is impossible to know accurately the monetary value of much of this work.

RESEARCH AT THE INSULAR STATIONS

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The only research work at Washington connected with the States Relations Service is that carried on in the Office of Home Economics. This work deals with matters affecting household practice rather than commercial interests, and it is impracticable to give the results a money value. For example, the results of investigations on human nutrition are being largely used by teachers, extension workers, physicians and nurses, and in the feeding of adults and children, but it would be very difficult to say with what financial result.

It is the function of this service to aid in the development of the National Extension System by studying the best methods of putting into practice the results of research of the department, the State college of agriculture, and practices of the best farmers.

Among some of the greater achievements of the various insular stations that have an immediate effect on the agriculture of their respective regions may be mentioned the following. No attempt is made to evaluate these services as they are continuing, and may have cumulative value as time goes on.

Plant breeding investigations in Alaska have developed varieties of grain adapted to the interior of that territory, and last year 6,000 bushels of wheat, barley, and oats were produced in the Tanana valley. By selection improvement varieties of vegetables and root crops have been produced that are especially adapted to the various localities. The strawberry breeding work has given Alaska hardy varieties of excellent quality.

The investigations at Kodiak have shown the practicability of stock raising in southwestern Alaska, cattle and sheep having been maintained on locally produced forage.

The investigations of the Hawaii station have shown the cause of a serious pineapple trouble and means for its control. As a result more than 4,500 acres have been replanted to pineapples where their cultivation had been abandoned. A former pathologist, while studying the root rots of other crops, discovered the cause of one of the most serious sugar cane diseases in Hawaii. His discovery was considered so important that the Hawaii Sugar Planters' Experiment Station took him from the government station, and is paying him more than double his former salary so that he may devote all his time to the sugar cane phase of the disease.

The Hawaii station determined the fertilizer requirements for rice when grown as a submerged crop, and as a result of its investigations ammonium sulphate is being largely substituted in many rice-growing regions for nitrate of soda, which is largely lost through nitrification and leaching. It has also shown the value of pigeon peas as forage and as a result hundreds of acres are now grown in Hawaii to replace forage formerly imported from the mainland.

Through its investigations the Guam station has been instrumental in improving the live stock of the island, introduced and developed many improved tropical crops, has found means for the production of permanent pastures under Guam conditions, and is quite rapidly bringing about an improvement in the agricultural practices of the people.

A former chemist in Porto Rico discovered the cause of a chlorosis

of sugar cane, pineapples, rice, and other crops, and in connection with his investigations he contributed valuable fundamental data on the soil and fertilizer requirements of crops in tropical regions. A station pathologist discovered the cause of one of the most serious diseases of the banana and demonstrated its control through selection breeding of resistant varieties. This disease occurs in all important banana regions of the Western Hemisphere.

Through its plant breeding work improved varieties of many crops have been obtained and important increases in food production in Porto Rico are attributed to the station's investigations. As a single example, Porto Rico formerly imported beans to the value of \$800,000 annually, but now most of them are locally produced, and in some years there is a surplus for export.

The Virgin Islands station has already produced a number of superior varieties of sugar cane, established Sea Island cotton as an industry, and has materially improved the quality of the corn grown in the islands.

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THE BIOLOGICAL SURVEY'S
SERVICE FOR THE PUBLIC WELFARE

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The entire practical work of the Biological Survey in promoting the conservation and increase of useful birds and mammals and in eliminating losses from injurious species is based absolutely on a foundation of scientific research, not only of the past but of that being continued at the present time and planned for the future. Furthermore, the practical work of the Bureau, which appears to be highly appreciated by the public, is the absolute outgrowth of its scientific investigations which began on a small scale without any idea that they would develop into such practical benefit to the public. These researches have demonstrated in a surprising way, often unexpectedly, the close relationship between many species of birds and mammals and the public welfare.

The available literature has been searched and hundreds of volunteer collaborators have added to the unparalleled store of information which has been amassed by the Bureau on the bird and mammal life of North America. The information files containing data relating to the birds and mammals of North America contain more than 1,500,000 cards, in addition to a very great number of manuscripts and a great amount of printed matter. In addition, the stomachs of more than 83,000 birds have been examined and their contents carefully determined under the microscope by trained experts for the purpose of accurately determining the food habits of the various species.

THE HISTORY OF THE
CITY OF BOSTON

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The history of the city of Boston is a subject of great interest and importance. It is a city of many centuries, and its history is a record of the growth and development of one of the most important cities in the world. The city has been the seat of many great events, and its history is a record of the progress of the human race. The city has been the home of many great men, and its history is a record of the achievements of the human mind. The city has been the center of many great movements, and its history is a record of the struggles of the human spirit. The city has been the birthplace of many great ideas, and its history is a record of the progress of the human race. The city has been the home of many great men, and its history is a record of the achievements of the human mind. The city has been the center of many great movements, and its history is a record of the struggles of the human spirit. The city has been the birthplace of many great ideas, and its history is a record of the progress of the human race.

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One of the most striking practical results of the investigations of the bureau has been the overwhelming proof derived from field observations, and the analysis of the contents of bird stomachs of the intimate relationship of insect-eating birds to successful agriculture. There are estimated to be more than 4,000,000,000 birds in the United States, a large portion of which are insect eaters. The birds are voracious feeders, and the gross mass, amounting to many thousands of tons, of injurious insects eaten by them every year unquestionably has a great influence in preventing the increase of species injurious to agriculture and related interests and the consequent increase of losses through these pests.

The publications by the Biological Survey of the food habits of insect-eating birds has demonstrated so clearly the value of this factor in assisting to maintain successful crop growing that, in addition to the Migratory Bird Treaty and the Federal Migratory Bird Treaty Act, practically all the States have passed laws within a comparatively few years stringently protecting insect-eating birds. In addition to its demonstration of the food habits of useful birds, the bureau is conducting an educational campaign for the increase of useful species. As a result of these combined efforts, there has been a marked increase in the numbers of many of the useful species, with the attendant increase in the benefits arising from their increasing war on insect pests. The researches of the bureau have established the fact that there is an average of about four birds to the acre, including migrants, in the United States. Placing the benefit to agriculture from the insects destroyed by these birds in their incessant warfare upon them at the insignificant sum of 10 cents each, the total annual benefit to agriculture from the work of insectivorous birds amounts to more than \$440,000,000 annually.

Not all of the foregoing sum can be attributed to the work of the Biological Survey, but the general appreciation of the value of birds to agriculture and the increase in their numbers due to their protection, and increase brought about through the investigations of the bureau and the educational campaigns it has been conducting, has substantially increased these benefits and is a strong factor in maintaining them.

Protecting Birds Internationally

The negotiation of the Migratory Bird Treaty Act with Great Britain for the protection of migratory birds in Canada and the United States, and the successful administration of the act to enforce the treaty has been possible only through the knowledge available from the scientific researches of North American bird life by the Biological Survey. At the time this treaty was negotiated the migratory game birds, such as ducks, geese, and their allies, were disappearing so rapidly through over-shooting that it was obvious many of our most valuable game birds would become practically extinct within a few years. Since the Migratory Bird Treaty Act became effective, in 1916, there has been notable increase not only in many insectivorous birds, but in our migratory wild fowl. Reports from all parts of the United States, year by year, record the increasing numbers of these valuable game birds, which amounts in the aggregate to many millions of dollars. In Minnesota sportsmen are required to make returns on the game killed by them, and the record for 1919 gives more than 1,800,000 ducks having been killed in that State, and in 1920 approximately an equal number. This is a value of nearly \$2,000,000 a year from migratory game birds in one State. It is believed the gross returns on migratory wild fowl for the entire United States year amounts to more than \$20,000,000, a large and increasing percentage of which is one of the results of scientific investigations into North American bird life conducted by the Biological Survey, thus giving it not only the data which was needed

1. The first part of the document is a list of names and dates, which appears to be a record of some kind. The names are written in a cursive script, and the dates are in a more formal, printed style. The list is organized into two columns, with names on the left and dates on the right.

to bring about the Migratory Bird Treaty and the act for its enforcement but also gives the necessary technical information for its successful administration. Continuous scientific investigations are an essential factor in the proper administration of this most successful conservation measure.

Control of Destructive Birds

A limited number of birds are destructive, as shown by the investigations of the bureau, and it has become one of its functions to investigate and develop methods for the control of such species. County agents in Utah have estimated that the destruction of English sparrows in that State through methods developed and recommended by the Biological Survey resulted in the saving of \$337,000 in three years. Methods developed by the Biological Survey for the control of injurious birds have been used in various other parts of the country for lessening losses by destructive species which have been very successful and have made great savings of crops aggregating a very large sum, but no definite figures can be given.

Research on the feeding habits of migratory wild fowl, such as ducks, geese, and other game birds, and methods for propagating the plants most important as food for these birds, has resulted in the growth in the business in the sale of these plants amounting to many thousands of dollars annually. Surveys of wild-fowl feeding grounds and recommendations for their improvement by the bureau experts has resulted in more than doubling the value of certain estates and in one instance the owner set the gain at a tenfold increase in value.

Rodents that Cost Millions

The investigations of the Biological Survey into the distribution and habits of the wild mammals have developed the fact that many species of rodents, such as prairie dogs, ground squirrels, jack rabbits, pocket gophers, pine mice, and others, do in the aggregate an enormous amount of damage to

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agriculture amounting to a total of more than \$300,000,000 a year. The scientific investigations into the species, their relationships, distribution, and habits has been fundamental to the development of the facts as to the enormous aggregate losses from these pests. In order to control and reduce these losses, long-continued scientific investigations were conducted for the development of poisons and methods for their use in the destruction of these animals on a large scale. The results have been so successful that during the last fiscal year 132,000 farmers and stockmen cooperated in poisoning rodent pests on more than 18,000,000 acres of crop and range land effecting a saving that year estimated at more than \$11,000,000. During the last three years the rodents have been poisoned on 44,800,000 acres of land. This work is done largely on a cooperative basis, and the States put into the work more than \$1,000,000 of cooperative funds, the work being conducted mainly under the direction of the Biological Survey. The total saving of crops due to the rodent work since 1916 is estimated to be more than \$43,000,000.

In addition to the losses from field rodents losses from house rats are estimated to exceed \$200,000,000 a year in the United States. Through the scientific investigations into these pests by the Biological Survey and the measures developed by it for their destruction and control great public interest has been aroused and campaigns are now being conducted actively in all parts of the country. The bureau is being asked continually to guide such campaigns or to give advice and to demonstrate methods of controlling house rats, not only for the benefit of the public but by various governmental organizations, including the War and Navy Departments. The total saving resulting from these rat campaigns amounts to many millions a year. There is no way of determining the approximate amount of the savings from this source but it runs unquestionably into many millions of dollars.

Losses from Predatory Animals

In addition to the work against rodent pests is that of controlling losses of live stock through predatory species such as wolves, coyotes, mountain lions, and others. The same fundamental scientific investigation as to the habits and distribution of the predatory animals has been the foundation for the successful work of the bureau in destroying these pests. In addition, a long continued series of investigations into the best poisons and poisoning methods to be used in the destruction of these animals has been necessary. Predatory animals are estimated to destroy annually more than \$20,000,000 worth of live stock in the western range States. In addition, they destroy probably an equal amount of game. The work of the bureau in destroying these animals has been so successful that urgent calls for assistance have come from Michigan, Missouri, Arkansas, and Oklahoma, in addition to the States farther west. Since the work was organized in the fiscal year 1916, 3,282 wolves, 615 mountain lions, 124,687 coyotes, 16,881 bob cats and lynxes, and a considerable number of stock-killing bears have been killed and their skins or scalps taken, making a total of 145,837 predatory animals thus destroyed. It is estimated that poison campaigns, which have been conducted on a great scale in many States, have killed coyotes equaling in number those of which the skins have actually been taken, thus making a total killed under the biological Survey campaigns against predatory animals in the West amounting to 291,674 animals. The value of live stock saved during the fiscal year 1920 through these efforts was estimated to equal \$6,000,000. The recent development of strikingly improved methods of poisoning will result within a comparatively few years in practically eliminating most of the losses of game and live stock from this source. The States appreciate the value of this control work against rodent and predatory animal pests to the extent, in many of them, of making appropriations to assist in the campaigns, specifically providing that the funds shall be spent in

cooperation with the bureau. The total saving of live stock through the predatory campaign since 1916 is estimated at more than \$16,000,000.

Fur Farming

The fur farming industry is developing rapidly in Canada and the United States, and has before it a great future. Since early in its development the scientific knowledge possessed by the Biological Survey concerning the fur bearers, their distribution and habits, has been of the greatest value in assisting in upbuilding this industry. An experimental fur farm has been established in northern New York where the bureau has an expert studying the diseases and parasites of fur bearers in captivity and methods of handling them, in order to give the public the benefit of such research. Results already obtained are of the utmost value. Investments in the fur-farming industry in the United States have already grown to millions of dollars in value and will increase steadily. Past investigations of the bureau and those now under way are providing knowledge of the utmost value for the benefit of the new industry and will add greatly to its success. Letters being received from leaders in the industry throughout the country express their appreciation of what the bureau is doing to assist them. This work is entirely based on careful scientific investigation.

Reindeer Industry in Alaska

Reindeer are domesticated descendants from the wild caribou from the northern parts of the Old World. The information possessed by the Biological Survey concerning the distribution and habits of the caribou in North America placed it in position to be of the utmost service in assisting to develop the reindeer industry of Alaska. From the time of the introduction of the original reindeer into Alaska, in 1892, up to about one year ago, practically no effort had been made to have the reindeer studied from a scientific point of view, and to organize the industry along modern lines, which it should follow as a

special phase of live-stock growing. The scientific knowledge possessed by the Biological Survey concerning native caribou, and other wild game, placed the bureau in an especially favorable position for developing the reindeer industry. This was recognized by the committee on agriculture and about a year ago an appropriation was made for the bureau to take up this work. A reindeer experiment station and laboratory was established in Alaska, and four experts have been making a careful and scientific study of the parasites and diseases of the reindeer, of the methods of range management, and of the principal plants eaten by the reindeer and their distribution in Alaska, for working out methods of range management in order that the industry may be handled on a proper basis. Results already obtained show that these investigations were needed urgently and have already obtained results which will be of the utmost importance in the industry. In fact, a number of the more intelligent reindeer owners in Alaska already are reorganizing the methods of handling their herds following suggestions made by bureau experts in the field.

The opportunities for the growth of the reindeer industry in Alaska are very great and these animals may form a valuable addition to the Nation's meat supply. In order to do this, however, the development of the industry must be based on scientific investigations which will result in the controlling of parasites and diseases and in a proper scientific knowledge of the distribution of forage plants and the apportionment of ranges based upon such knowledge. The precarious situation in many of the reindeer herds in Alaska to-day shows the urgent need of putting into practice the scientific knowledge which is being obtained through the work of the bureau.

Game and Bird Reservations

The Biological Survey has charge of nearly all Federal big game and bird reservations. The scientific investigations of the bureau into the wild life of the country and its knowledge of the game and nongame birds and mammals give

it the basis on which to manage such reservations successfully. The number of wild fowl and game animals on the reservations is constantly increasing. This is particularly the case on the fenced large game reservations, the greatest of which, the Bison Range in Montana, now has 383 buffalo, 260 elk, 26 deer, and 60 antelope. The other Government bureaus having to do with game or wild life incidental to their other activities recognize the fact that the Biological Survey is the storehouse for knowledge on wild life, and apply to it continually for information and for guidance in solving their problems relating to game and nongame birds and mammals. Such applications come from the Forest Service, National Parks Service, and elsewhere.

Prevention of Imported Pests

One of the duties of the bureau is to control the importation of wild birds and mammals from abroad in order that the introduction of birds or mammals which may become pests may be prevented. The importance of this phase of the work is indicated by the fact that only through the active intervention of the bureau has the introduction of the mongoose into the United States been prevented. The introduction of these pests into the Hawaiian Islands, Jamaica, and elsewhere has shown them to be so exceedingly destructive to domestic fowl and to all kinds of ground-living game birds and small mammals that their introduction into the United States would be a calamity of the worst description. It would mean the loss of hundreds of millions of dollars a year to the country. The greatest vigilance is needed in preventing these pests from coming in.

In connection with the work of keeping pests out of the United States, the Biological Survey was instrumental in preventing the introduction of the mongoose into Costa Rica where, not being aware of the pernicious character of this animal, the Government, several years ago, contemplated its introduction to control rats. The introduction of the mongoose into Costa Rica would result in its prompt extension of range up through Central America and Mexico to the United States. At the request of a Costa Rican official a vigorous protest against the introduction of these animals into that country, basing the protest on a statement of the already certain results which would ensue, was successful in causing the abandonment of the project. The activities of this bureau in preventing the introduction of this pest into the United States alone is worth each year many times the total cost of the bureau since its organization. The keeping out of pests like the mongoose, and others, can be done only through the results of scientific investigation and knowledge concerning the pests, their distribution and habits, which is a part of the scientific work of the bureau.

Control of Diseases Spread by Wild Animals

The scientific investigations of the Biological Survey in determining the species of animals, their relationships and distribution, and the methods of their control or destruction, have proved to be of the utmost value in connection with the control of the spread of such destructive diseases as bubonic and pneumonic plagues, spotted fever, and rabies, this being an incidental outcome to the work being done in the interest of agriculture. Not only house rats, but ground

squirrels and some other native rodents, have been proved to be plague carriers. The ground squirrels of Montana are carriers of the dreaded spotted fever and predatory animals in California, Oregon, Washington, Idaho, Nevada, and Utah have been carriers and disseminators on a great scale of rabies. The knowledge of the Biological Survey concerning the habits and distribution of the species of these native animals, and its development of methods for their destruction on a great scale, are of the most vital importance in connection with the spread of any mammal-borne epidemic of the character mentioned. The effectiveness of the work in destroying predatory animals afflicted with rabies in the six States mentioned has been shown in checking the spread of that disease which otherwise undoubtedly would have covered the entire Rocky Mountain region. The extensive work in the destruction of ground squirrels and other rodent pests will be equally effective in checking the spread of bubonic and pneumonic plagues from the Pacific Coast to the interior of the country, and should an outbreak occur the information available would be sufficient to immediately take the most effective steps to control and destroy the carriers on a great scale so that the full development of the disease could be prevented. The value of the service to the country in checking the spread of rabies from the six States named throughout the remaining States in the West can not be given in definite figures but, judging from the enormous losses of live stock from that source at the time the bureau began its campaign, which are estimated to have amounted to \$500,000 in one year in Nevada, and in the fact that more than 1,500 people were bitten by rabid animals and a considerable number of deaths took place from such bites, is sufficient

indication of the results which would have followed such a spread of the disease.

General Service

The scientific investigations into the wild life of North America, which the Biological Survey has conducted has given it a fund of information unequal in any other institution in the world concerning a similar area. As a result, the bureau is recognized as a kind of clearing house for information on all subjects relating to the wild life of the country, and is being asked constantly for assistance and guidance in problems relating particularly to the conservation of our wild life resources, both in connection with the activities of the Federal and State Governments and private individuals. Foreign Governments also come to us for similar information. The value of the results of such guidance can not be stated in terms of dollars and cents, but the aggregate worth to the country at large of having ready a source of information of this character must aggregate a large sum.
